NDCEE

National Defense Center for Energy and Environment

DoD Executive Agent

Office of the Assistant Secretary of the Army (Installations and Environment)

Corn Hybrid Polymer Media for Coatings Removal from Delicate Substrates

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The NDCEE is operated by: CTC Concurrent Technologies Corporation

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
MAY 2008		**00-00-2008 to 00-00-2008**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Corn Hybrid Polymer Media for Coatings Removal from Delicate Substrates	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **National Defense Center for Energy and Environment,Operated by Concurrent Technologies Corporation,100 CTC Drive,Johnstown,PA,15904**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
JSEM - Joint Services Environmental Management Training Conference & Exposition Conference, 5-8 May 2008, Denver, CO.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**34**	

Presentation Outline

- Background
- Objectives
- Technology Overview
- Proof-of-Concept Evaluation
- Demonstrations

Background

- Coatings removal and selective stripping techniques are performed routinely during maintenance, repair, and overhaul activities
- Current processes include chemical strippers, media blasting, and manual coatings removal methods that often result in:
  - Substrate damage
    - Unnecessary rework
    - Reduced part life
  - Solvent vapor release
  - Hazardous waste generation
  - Unsafe working conditions
- Past efforts evaluated several alternative coatings removal technologies
- Corn-based blasting media
  - Provides acceptable stripping rates
  - Does not damage delicate substrates
  - Generates biodegradable and recyclable material

Objectives

- Evaluate corn-based blasting media for removing coatings from delicate substrates
- Evaluate overall coatings removal efficacy and cost feasibility
- Determine if the process meets stakeholder requirements
- Identify approval authorities and implementation paths for corn-based blasting media at DoD facilities
- Determine feasibility and help facilitate field implementation

Corn Hybrid Polymer (CHP) Media (eStrip™ GPX)

- Polycrystalline cornstarch material
- 100% organic, non-toxic, and biodegradable
- Operating pressures range from 20-35psi
- Used in standard light abrasive blast equipment
- Considered a “drop-in” replacement for many plastic media blasting (PMB) systems
  - Meets MIL SPEC for Type VII PMB
  - Approved as Type VII by the USAF
- Generates minimal waste
- Manufactured by Archer Daniels Midland (ADM)
- Sole Government distributor is Midvale Environmental Technologies

CHP Demonstration Facility

Midvale's mobile demonstration facility

The mobile facility includes a fully enclosed blast room, media delivery system, material recovery system, and personal protective equipment

- Demonstrations were conducted inside of Midvale's mobile demonstration facility, facility blast booths, or in-situ (ship bulkhead)
- Media is recovered inside of the mobile facility and then disposed of by host facility personnel or Midvale

Overview of Demonstrations

- Naval Station (NS) Mayport Proof-of-Concept Evaluation
- Demonstrations
  - Naval Submarine Base (NSB) Kings Bay
  - Helispec (Fort Rucker)
  - NS Mayport
  - Robins Air Force Base (AFB)
  - Corpus Christi Army Depot (CCAD)

Proof-of-Concept Evaluation
NS Mayport

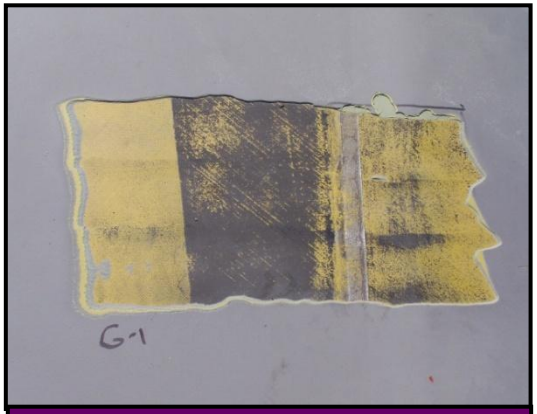
- Proof-of-concept evaluation performed February 14-15, 2006
- Participants/Stakeholders
  - In-Service Support Center (ISSC) Jacksonville (NAVAIR)
  - Fleet Readiness Center Southeast (FRCSE)
  - Robins AFB
  - Aircraft Intermediate Maintenance Detachment (AIMD) Mayport
  - Southeast Regional Maintenance Center (SERMC) Mayport
  - NSB Kings Bay Trident Refit Facility (TRF)
  - Blount Island Command (USMC Prepositioning Programs)
  - NASA
- Calculated and recorded coatings removal rates and stakeholders' visual observations respectively.
- Performed a cost analysis for selected components.

Proof-of-Concept Components Evaluated

- C-130 spinner cap
  - Baseline: 0.6 ft^2/hr
  - CHP: 9.8 ft^2/hr
- F-15 speed brake
  - Baseline: 0.3 ft^2/hr
  - CHP: 9.1 ft^2/hr
- MK-92 radome panel
  - Baseline: 4.0 ft^2/hr
  - CHP: 29.7 ft^2/hr
- P-3 radome panel
  - Baseline: 3.0 ft^2/hr
  - CHP: 12.3 ft^2/hr
- SH-60 helicopter blade
  - Baseline: 1.0 ft^2/hr
  - CHP: 9.0 ft^2/hr
- HMMWV hood
- PCMS tiles
- NASA windbrake panels
- T-45 speed brake
- EP-3 blade antenna
- F-18 antenna cover
- Surface ship life raft shell
- LM2500 gas turbine engine bullet nose
- Locker shield
- AS2815 UHF antenna

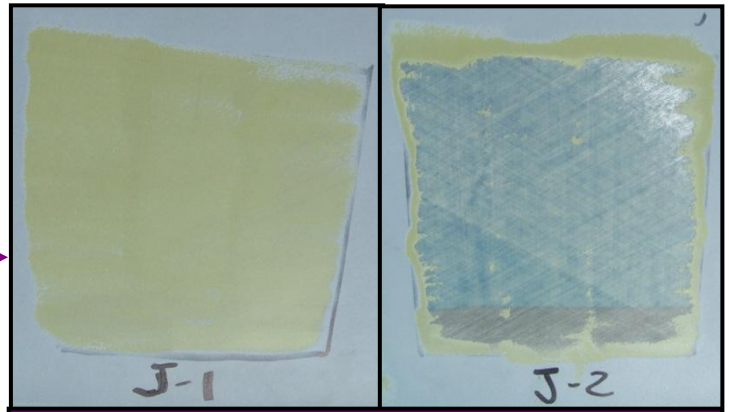
Proof-of-Concept Results (cont.)

F-15 speed brake
(Fiberglass substrate)
(prior to coating removal)



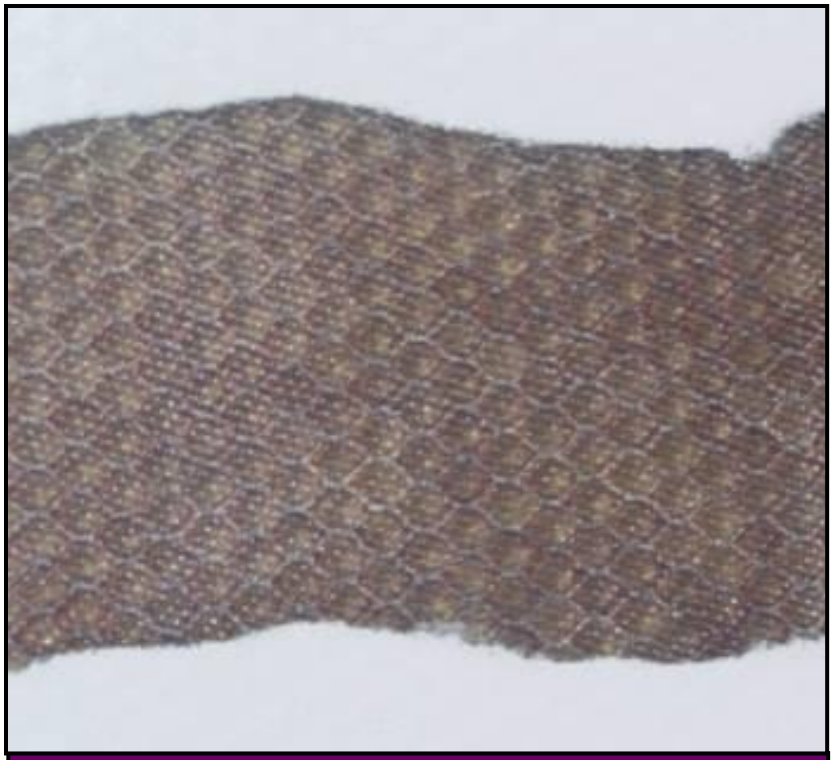
Coating removed to the primer at a rate of 9.1 ft^2/hr (@ 33psi) with no resulting visible substrate (fiberglass) damage

SH-60 helicopter blade
(Titanium/fiberglass/carbon graphite substrate)
(prior to coating removal)



Coating removed to the primer (left) at a rate of 29 ft^2/hr (@ 26psi) and to the substrate (right) at a rate of 9 ft^2/hr (@35 psi), with no resulting visible substrate (titanium/fiberglass/carbon graphite) damage in either case

Proof-of-Concept Results (cont.)



Coating removed from P-3 radome panel (polyester fiberglass) at a rate of 12 ft^2/hr with no visual damage

Coating removed from C-130 spinner cap at a rate of 10 ft^2/hr with no visual damage to the substrate (fiberglass) or embedded electrical wires

Cost Analysis

Component	Facility	Baseline Process	Estimated Annual Cost Savings
C-130 Spinner	Robins AFB	Hand Sanding	$1,627,309
F-15 Speed Brake		Hand Sanding	$198,026
P-3 Orion Nose Radome	FRC SE	Hand Sanding/Chemical	$38,666
MH-60 Helicopter Blade	AIMD	Hand Sanding	$19,510
MK-92 Radome	SERMC	Hand Sanding	$56,991

NSB Kings Bay Demonstration

- Based on the successful proof-of-concept evaluation, personnel in attendance from NSB Kings Bay TRF requested a CHP demonstration at their facility
- Demonstration performed March 21-22, 2006
- Components Evaluated:
  - Ice Cap
    - Baseline: 1.0 ft^2/hr CHP: 32.7 ft^2/hr
  - Navigational Sonar System (NSS) Window
    - Baseline: 0.79 ft^2/hr CHP: 25.7 ft^2/hr
  - Sail Window
    - Baseline: 5.5 ft^2/hr CHP: 34.4 ft^2/hr
  - Clam Shell Hatch
    - Baseline: 0.4 ft^2/hr CHP: 4.3 ft^2/hr
- Combined cost analysis for these components showed an annual operating cost savings of $76,617

Helispec (Fort Rucker) Demonstration

- Conducted on U.S. Army helicopter substrates on August 22-24, 2006 at Helispec facility in Brantley, AL
  - Coordinated Efforts
    - AMCOM
    - Fort Rucker Aviation Center Logistics Command (ACLC)
    - U.S. Army Research, Development, and Engineering Command (RDECOM)
    - CCAD
- Calculated and recorded coatings removal rates and stakeholders' visual observations respectively. Coatings removed at acceptable rates (per Fort Rucker ACLC and RDECOM feedback) with no visible substrate damage

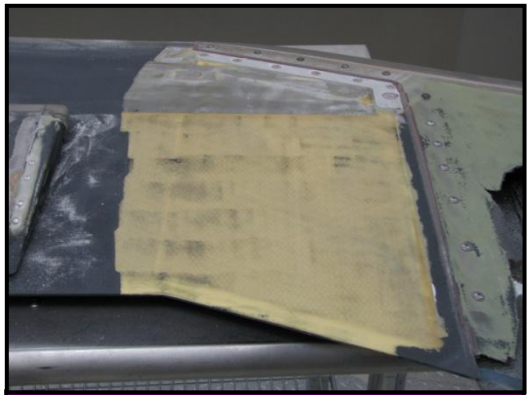
Helispec (Fort Rucker) Components Evaluated

- UH-60 Rotor Blade (Kevlar)
  - CHP: 34.4 ft^2/hr
- OH-58 Radio Compartment Door (aluminum)
  - CHP: 24.3 ft^2/hr
- OH-58 Pilot Door (aluminum)
  - CHP: 12.9 ft^2/hr
- UH-1H Tail Rotor Blade (honeycomb aluminum)
  - CHP: 17.7 ft^2/hr (to primer), 8.7 ft^2/hr (to substrate)
- UH-1H Elevator Skin (aluminum)
  - CHP: 23.1 ft^2/hr
- UH-1H Transmission Mount (cast iron)
  - CHP: 37.5 ft^2/hr
- OH-58 Cowling Cover (fiberglass)
  - Removal rate not determined

Helispec Demonstration Results

UH-60 rotor blade
(Fiberglass substrate with sections of aluminum lightning mesh)
(prior to coating removal)

Coatings removed to fiberglass substrate at a rate of 34.4 ft^2/hr (@ 32psi) with no substrate damage



Coatings removed from fiberglass as well as a section of aluminum lightning mesh

NS Mayport Demonstration

- Based on proof-of-concept results, a demonstration was performed at NS Mayport on October 16-24, 2006
- Participants/Stakeholders
  - ISSC
  - FRCSE
  - SERMC Mayport

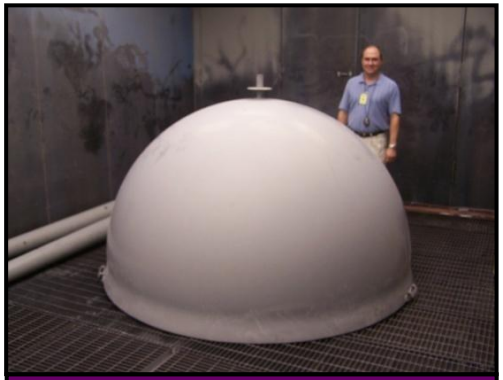
NS Mayport Components Evaluated

- MK-92 Radome (top half)
  - CHP: 36 ft^2/hr (@25psi)
- HMMWV Hood
  - CHP: 20.9 ft^2/hr (@38psi)
- T-45 Seal
  - CHP: 40.1 ft^2/hr (@38psi)
- UH-60 Blackhawk Rotor Blade
  - CHP: 25.7 ft^2/hr (@32psi)
- P-3 Radome
  - CHP: 10.9 ft^2/hr (@32psi)
- PCMS Tiles (removed panels)
  - CHP: 100.8 ft^2/hr (@20psi) to primer
  - CHP: 67.2 ft^2/hr (@20psi) to substrate

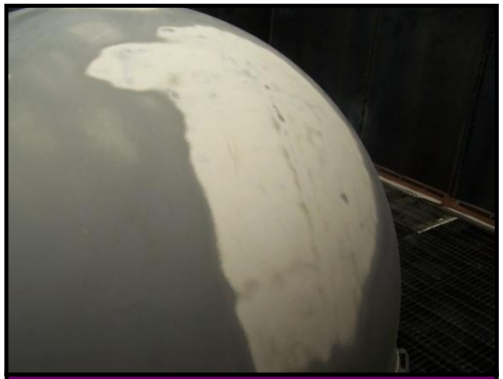
- SERMC Antenna Repair Shop blast booth was used for the MK-92 Radome
- Prototype containment system was used for in-situ PCMS tiles coatings removal from the USS Simpson (FFG 56)

MK-92 Radome

Photo: www.navy.mil



MK-92 Radome in SERMC Antenna Repair Blast Booth



MK-92 Radome with Area of Coating Removed using CHP

MK-92 Radome Close-up of Blasted Area

- MK-92 Radome (fiberglass honeycomb substrate)
  - Surface Area: 250 ft^2
  - Baseline hand sanding: 4 ft^2/hr = 62.5 hrs/part
  - CHP: 36 ft^2/hr (@25psi) = 7 hrs/part
  - Labor savings: 55.5 hrs/part

Robins AFB Demonstration

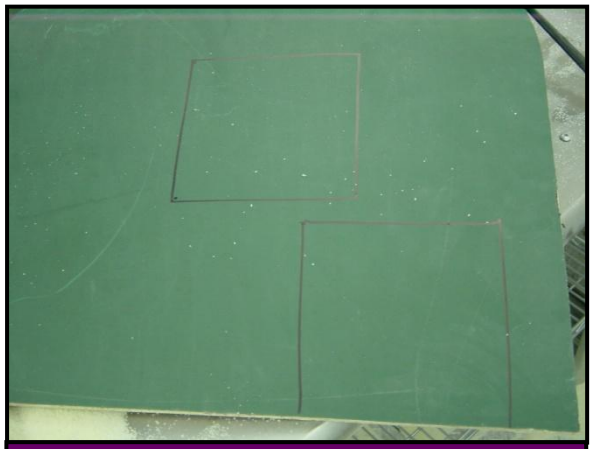
- Demonstration performed February 13-14, 2007
- Components Evaluated
  - C-130 Spinner Cap
  - MC-130H Nose Radome
  - C-130 Hat Dome
  - C-130 Tail Cove
- Robins AFB personnel determined through visual inspection that the CHP media stripped all components with no visible damage to the delicate substrate materials.

MC-130H Nose Radome

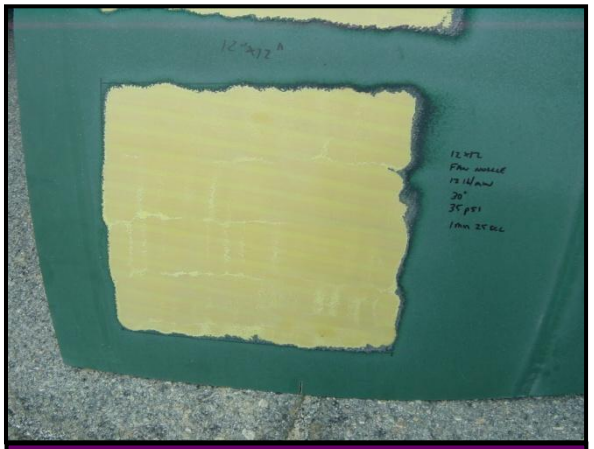
Photo: U.S. Air Force

- Fiberglass Honeycomb Substrate
- Coating System:
  - MIL-PRF-23377 Type 1 Primer
  - MIL-C-83231 Type II Polyurethane Rain Erosion Coating
  - MIL-C-85285 Polyurethane Topcoat
- Strip Rate 42.35 ft^2/hr (@35psi)
- Coating removed to bare fiberglass substrate
- No visible substrate damage

Scrap MC-130 Nose Radome for Demonstration



Panel Cut from MC-130 Radome Prior to CHP Blasting



Coating Removed from Panel
One Square Foot, 1 Minute, 25 Seconds

CCAD Demonstration

- Conducted on U.S. Army helicopter substrates on March 11-13, 2008
- Participants
  - CCAD
  - RDECOM
- Calculated and recorded coatings removal rates and stakeholders' visual observations respectively

CCAD Components Evaluated

- UH-60 Blackhawk Main Rotor Blade
- UH-60 Blackhawk Blade Cuff
- UH-60 Blackhawk Tip Cap
- UH-60 Blackhawk Tail Rotor Blade
- UH-60 Blackhawk Tail Rotor Pitch Control Arm
- UH-60 Blackhawk Stabilator
- UH-60 Blackhawk Tail Gear Case Housing
- UH-60 Blackhawk Bottom Transmission Sump Housing
- AH-64 Apache Tail Blade

UH-60 Blackhawk Rotor Blade

Photo: U.S. Army

- Fiberglass Honeycomb Substrate with Aluminum Lightning Mesh
- Coating System:
  - MIL-PRF-23377 Primer
  - MIL-C-46168 Topcoat
- Strip Rate 15.3 ft^2/hr (@30psi) (Baseline: 1.5 ft^2/hr)
- Coating removed to bare fiberglass substrate
- No visible substrate damage

UH-60 Rotor Blade Section
Prior to CHP Blasting

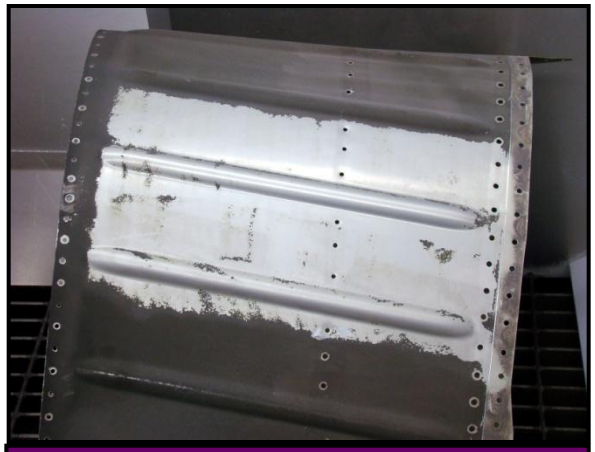
UH-60 Rotor Blade Section
CHP Blasting Various Pressures

UH-60 Blackhawk Stabilator

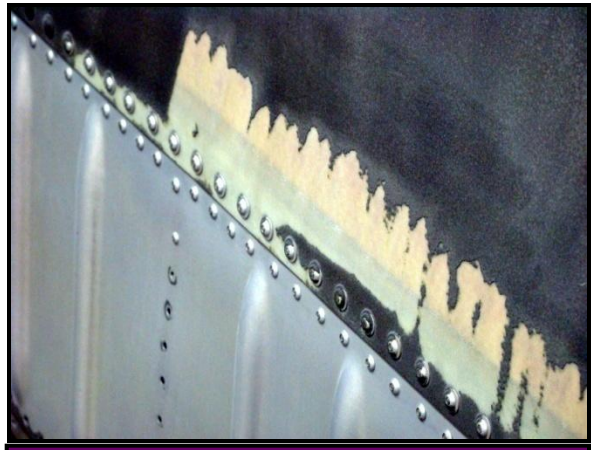
Photo: U.S. Army

- Aluminum and Kevlar Substrates
- Coating System:
  - MIL-PRF-23377 Primer
  - MIL-C-46168 Topcoat
- Strip Rate: Aluminum Section: 32.1 ft^2/hr (@25psi)
  (Baseline: 34.5 ft^2/hr)
  Kevlar Section: 15.1 ft^2/hr (@32psi)
  (Baseline: 2.05 ft^2/hr)
- Coating removed to bare substrates
- No visible substrate damage

UH-60 Blackhawk Stabilator Prior to CHP Blasting



UH-60 Blackhawk Stabilator Aluminum Panel After CHP Blasting



UH-60 Blackhawk Stabilator Kevlar Section After CHP Blasting

Summary

- Based on these demonstrations, CHP has been implemented or is in the process of implementation at:
  - FRCSE
  - Robins AFB
  - NSB Kings Bay TRF
- Demonstrations have shown CHP to be effective without damage to delicate substrates and have shown substantial stripping rate increases over baseline coatings removal methods.

Acknowledgements

- **NDCEE Executive Agent** — Mr. Tad Davis, DASA (ESOH)
- **NDCEE Program Director** — Mr. Hew Wolfe, ODASA (ESOH)
- **NDCEE Program Manager** — Dr. Charles Lechner, ODASA (ESOH)
- **NDCEE Contracting Officer's Representative** — Mr. Tom Moran, ODASA (ESOH)

NSWCCD
USAEC
ISSC Jacksonville
FRCE
NSB Kings Bay
NASA AP2
AMCOM
USMC
Simmon AAF, Fort Bragg

U.S. Navy CNO, N45
NAVAIR
FRCSE
NS Mayport
Robins AFB
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This work was funded through the Office of the Assistant Secretary of the Army (Installations and Environment) and conducted under contract W74V8H-04-D-0005 Task 0429.

Back-up/Support Slides

Proof-of-Concepts Results

Component	Coating System	Substrate	BASELINE PROCESS			CHP		
			Process	Strip rate (ft^2/hr)	Comments	Nozzle Pressure (psi)	Strip rate (ft^2/hr)	Observations
C-130 Spinner	Surface primer with polyurethane erosion resistant coating (7-9 mils total)	Fiberglass with electrical wires embedded	Hand Sanding	0.6	Significant damage to substrates and wires embedded within	35	**9.8**	Coating removed to the substrate with no visible damage
F-15 Speed Brake	Wash Primer, followed by polyurethane, finished with antistatic topcoat (15 mils total)	Fiberglass	Hand Sanding	0.3	Extremely time consuming and substrate damage often noted	33	**9.1**	Coatings removed to primer with no visible substrate damage
P-3 Radome	Epoxy primer and polyurethane topcoat (10 mils total)	Polyester fiberglass	Hand Sanding	3.0	Extremely time consuming and substrate damage often noted	23	**12.3**	100% removal of topcoat and primer with no visible substrate damage
SH-60 Helicopter Blade	Polyurethane	Titanium, fiberglass, and carbon graphite matrix	Hand Sanding	1.0	Fiber waste is not contained and sanding process is not worker friendly	26	**29.0**	Coating removed to primer with no visible substrate damage
						35	**9.0**	Coating removed to substrate with no visible damage
MK-92 Radome	Enamel (7-9 mils)	Honeycomb fiberglass	Hand Sanding	4.0	Extremely time consuming and labor intensive	37	**29.7**	Topcoat and 50% of first primer removed with no visible substrate damage
						37	**32.1**	Coating removed to primer on majority of area and selectively removed to the substrate in one small area

NSB Kings Bay Demonstration Results

Component	Coating System	Substrate	BASELINE PROCESS			CHP		
			Process	Strip rate (ft^2/hr)	Comments	Nozzle Pressure (psi)	Strip rate (ft^2/hr)	Observations
Ice Cap	Epoxy primer and antifoulant topcoat ("Mare Island" 150/151)	Fiberglass (polyester)	PMB followed by Hand Sanding	1.0	1 hour with PMB (significant damage), 8 hours of hand sanding	27	**32.7**	Antifoulant topcoat removed to the primer with no visible substrate damage
NSS Window	Epoxy primer and antifoulant topcoat	Kevlar	PMB followed by Hand Sanding	0.79	1 hour with PMB (significant damage), 12 hours of hand sanding, followed by several steps of repair due to substrate damage	23	**25.7**	Antifoulant topcoat removed to the primer with no visible substrate damage
Sail Window	Epoxy primer and antifoulant topcoat	Fiberglass	PMB	5.5	Significant substrate damage often noted	40	**34.4**	Antifoulant topcoat removed to the primer with no visible substrate damage
Clam Shell Hatch	Epoxy primer and antifoulant topcoat ("Mare Island" 151/153)	Fiberglass	Hand Sanding	0.4	Extremely time consuming	28	**4.3**	Layered coating remaining - would need to optimize the CHP process for this application

Helispec Demonstration Results

Component	Substrate	Baseline Process	CHP		
			Nozzle Pressure (psi)	Strip rate (ft^2/hr)	Observations
UH-60 Rotor Blade	Kevlar with Section of Aluminum Lightning Mesh	Hand Sanding	32	**34.4**	Coating removed completely to substrates (i.e., Kevlar and aluminum) with no visual substrate damage
OH-58 Radio Compartment Door	Aluminum	Chemical Stripping/Hand Sanding	35	**24.3**	Topcoat and the majority of the primer removed with no visible damage to the underlying substrate
OH-58 Pilot Door	Aluminum	Chemical Stripping/Hand Sanding	35	**12.9**	Topcoat and the majority of the primer removed with no visible damage to the underlying substrate
UH-1H Tail Rotor Blade	Honeycomb Aluminum	Chemical Stripping/Hand Sanding	30	**17.7**	Coatings removed to the primer with no visual damage to the underlying substrate
			35	**8.7**	80% of the primer removed with no visual damage to the underlying substrate
UH-1H Elevator Skin	Aluminum	Chemical Stripping/Hand Sanding	35	**23.1**	Coatings completely removed to the substrate with no visible damage
UH-1H Transmission Mount	Cast Iron	Chemical Stripping/Hand Sanding	32	**37.5**	Coatings completely removed to the substrate with no visible damage

NS Mayport Demonstration Results

Component	Substrate	Baseline Process	CHP		
			Nozzle Pressure (psi)	Strip rate (ft^2/hr)	Observations
HMMWV Hood	Fiberglass	Various	38	**20.9**	CARC topcoat removed to primer with no visual substrate damage
T-45 Seal (access panel)	Aluminum	Not determined	38	**40.1**	Coating and primer removed
UH-60 Blackhawk Rotor Blade	Kevlar with Section of Aluminum Lightning Mesh	Hand Sanding	32	**25.7**	Coating removed completely to substrates (i.e., Kevlar and aluminum) with no visual substrate damage
P-3 Radome	Polyester Fiberglass	Hand Sanding	32	**10.9**	Coating removed completely to substrate with no visual substrate damage
MK-92 Radome	Fiberglass Honeycomb	Hand Sanding	25	**36**	Coating removed to primer with no visual substrate damage
PCMS Tile (Panel)	Foam	Chemical	20	**100.8**	Selective stripping of topcoat only
			20	**67.2**	Removal to substrate

CCAD Demonstration Results

Component	Substrate	Baseline Process	CHP		
			Nozzle Pressure (psi)	Strip rate (ft^2/hr)	Observations
UH-60 Blackhawk Main Rotor Blade	Titanium and fiberglass with lightning mesh covering portions of fiberglass	Hand Sanding	30	**15.3**	Coating and primer removed
UH-60 Blackhawk Tip Cap	Graphite composite with nickel abrasion strip on edge. Portions covered with copper and stainless steel mesh.	Hand Sanding	25	**33.5**	Coating removed to primer
UH-60 Blackhawk Tail Rotor Blade	Fiberglass with aluminum lightning mess covering entire surface	Hand Sanding	30	**23.5**	Coating removed to lightning mesh
UH-60 Blackhawk Stabilator	Aluminum and Kevlar sections	Al: PMB Kevlar: Hand Sanding	Al: 25 Kevlar: 30	Al: 32.1 Kevlar: 15.1	Coating and primer removed